B11 concl.

or using DCTs and IDCTs for blocks of size N/2 x N/2 and without using DCTs or IDCTs of length N x N; and

- means for transmitting to the first one of the users a bit stream including only the calculated coefficients. --

REMARKS

Reconsideration and allowance of the subject application are respectfully requested.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached pages are captioned "**Version With Markings To Show Changes Made**."

Applicants note with appreciation the Examiner's indication of allowable subject matter in claims 3, 7, 13, and 17. For the reasons set forth below, Applicants respectfully submit that the other claims are also in allowable form.

Claims 1-2, 4-6, 8-12, 14-16, and 18-21 stand rejected under 35 USC §103 as being unpatentable over U.S. Patent No. 5,107,345 to Lee. This rejection is respectfully traversed.

Lee describes a method for compressing image data and employs a subsystem for generating from a block of input pixel data a corresponding composite block of discrete cosine transform data. The subsystem also performs a Discrete Cosine Transform (DCT) on at least one predetermined level of constituent sub-blocks of the block of pixel data. The DCT transform outputs corresponding block and sub-blocks of DCT coefficient values.

As the Examiner admits, Lee does not disclose or suggest that it would be possible or advantageous to calculate a DCT of length N from DCTs of length $N/2$. In the example where $N = 16$, the present invention permits a DCT for a $16x16$ pixel block to be obtained when only DCTs of $8x8$ pixel blocks are supported by existing hardware and/or software. Despite the Examiner's recognition of Lee's deficiencies, the Examiner opines it would have been obvious

> to take advantage of Lee's teaching [of using sub-blocks] and modify the system [Lee's system] since Lee '435 in particular describe an adaptive DCT scheme coding and mentioned using variable block size for the benefit of the desired design, like speed up the processing (i.e., column 8, lines 50+).

In essence, the Examiner believes it would be obvious to change Lee to calculate a DCT of length N directly from two sequences of coefficients of length $N/2$ because Lee teaches an adaptive

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block size DCT compression scheme. Such a change is obvious only after reading the instant application.

Lee's idea is directed to something different than calculating longer length DCTs from shorter DCTs. In column 8, lines 28-35, Lee explains:

> The main distinction of the compression scheme of the present invention resides in the fact that the 16x16 block is adaptively divided into sub-blocks with the resulting sub-blocks at different sizes also encoded using a DCT process. By properly choosing the block sizes based on the local image characteristics, much of the quantization error can be confined to small sub-blocks.

Lee's invention divides pixel blocks into sub-blocks to limit quantization error. Lee does <u>not</u> avoid the need to calculate a DCT of length N. For example, beginning at column 9, lines 13-14, Lee describes that the "*16 x 16 pixel block* is input to a *16 x 16 two-dimensional discrete cosine transform (DCT)* element 10a" (emphasis added). In addition, that same 16 x 16 pixel block is also "input as four 8 x 8 pixel blocks to 8 x 8 DCT element 10b, as eight 4 x 4 pixel blocks to 4 x 4 DCT element 10c, and as sixty-four 2 x 2 pixel blocks to 2 x 2 DCT element 10d." Column 9, lines 15-18. Each one of these DCT elements 10a-10d performs two-dimensional DCT operations on each respectively sized input block of pixel data. Specifically, "DCT element 10a performs a single 16 x 16 transform operation." Column 9, lines 23-24. Transform coefficients from each of the four DCT elements 10a-10d are provided to a respective quantizer lookup table 12a-12d.

Thus, there is no teaching in Lee or other prior art to support changing Lee to be like the present invention. Lee is perfectly happy calculating a DCT of length N and assumes that there is DCT element, i.e., DCT element 10a where N=16, to perform that size of DCT transform operation. In contrast, the present invention does not make that assumption. As one example, if circuitry exists and/or it is desirable to perform 8 x 8 DCT transforms, the present invention provides a way to obtain DCTs for 16 x 16 pixel blocks from the 8 x 8 DCT transforms. A 16 x 16 DCT transform need not be used. This flexibility/capability is either disclosed nor suggested in Lee. Nor does Lee suggest calculating a DCT of length N x N directly from four sequences of coefficients produced by calculating a DCT of length N/2 x N/2 without using DCTs of length N x N.

As the Examiner is aware, there must be some teaching or suggestion to modify a reference in a way that results in the claimed invention.[1] The Examiner seems to be suggesting that Lee *could*

[1] See *Northern Telecom, Inc. v. Datapoint Corp.*, 908 F.2d 931, 934 (Fed. Cir. 1990).

be modified to use the present invention. Nonetheless, the "mere fact that the prior art could be so modified would not have made the modification obvious unless the prior art suggested the desirability of the modification."[2] Lee simply does not provide the necessary motivation, and the only way one can arrive at the modification proposed by the Examiner is by reading the instant application.

All claims are novel and non-obvious in view of Lee. The application is therefore in condition for allowance. An early notice to that effect is earnestly solicited.

Respectfully submitted,

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[2] *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984).

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE ABSTRACT:

Please insert the following Abstract as a separate page:

A Discrete Cosine Transform (DCT) for an entire original sequence is obtained using the DCT coefficients representing the first half and the second half of the original sequence. This is useful when calculation of DCTs of a certain length is supported by hardware and/or software and different size DCTs must be calculated. Example areas of application include still image and video transcoding and scalable image and/or video coding.

IN THE SPECIFICATION:

The paragraph beginning at page 2, line 31 and continuing through page 3, line 5:

-- This transcoding might [has] <u>have</u> to implement a spatial resolution reduction of the video in order to fit into the bandwidth of a particular receiver. For example, an ISDN subscriber might be transmitting video in Common Intermediate Format (CIF) (288x352 pixels), while a PSTN subscriber might be able to receive video only in a Quad Common Intermediate Format (QCIF) (144x176). Another example is when a particular receiver does not have the computational power to decode at a particular resolution and therefore a reduced resolution video has to be transmitted to that receiver. Additionally, transcoding of HDTV to SDTV requires a resolution reduction. --

IN THE CLAIMS

1. *(Amended)* An encoder <u>or decoder, comprising:</u>

-[having] <u>first processing circuitry</u> [means] for calculating <u>a discrete cosine transform (DCT)</u> [the DCT] of [a sequence of] length N/2, N being a positive, even integer, <u>to produce two sequences of coefficients of length N/2, that represent the first and second half, respectively, of an original sequence of values of length N,</u> <u>and</u>

[characterised by

- [means] <u>second processing circuitry</u> for calculating a DCT of length N directly from <u>the</u> two sequences of <u>coefficients of</u> length N/2 [representing the first and second half of an original sequence of length N].

2. *(Amended)* An encoder or decoder comprising:

- [having means] first processing circuitry for calculating a discrete cosine transform (DCT) [the DCT] of [a sequence of] length N/2 x N/2, N being a positive, even integer, to produce four sequences of coefficients, and **[characterised by]**

- [means] second processing circuitry for calculating a [an N x N] DCT of length N x N directly from the four sequences of coefficients [DCTs of length (N/2 x N/2) representing the DCTs of four adjacent blocks constituting the N x N block].

3. *(Amended)* [An] The encoder or decoder of [according to any of claims] claim 1 [or 2], wherein [**characterised in** that] the second processing circuitry [the means] for calculating DCT [DCTs] of length N [N/2 are] is arranged to calculate the even coefficients of [a] the DCT of length N as:

$$
\begin{aligned}
X_{2k} &= \sqrt{\frac{2}{N}}\varepsilon_{2k}\sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)2\kappa\pi}{2N} \\
&= \sqrt{\frac{2}{N}}\varepsilon_k\left\{\sum_{n=0}^{\frac{N}{2}-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=N/2}^{N-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)}\right\} \\
&= \sqrt{\frac{2}{N}}\varepsilon_k\left\{\sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=0}^{\frac{N}{2}-1} x_{N-1-n} \cos\left[\frac{[2(N-1-n)+1]\kappa\pi}{2(N/2)}\right]\right\} \\
&= \sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1} z_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)}\right\} \\
&= \sqrt{\frac{1}{2}}\left[Y_k + (-1)^k Z_k\right] \\
&= \sqrt{\frac{1}{2}}\left[Y_k + Z'_k\right] \qquad k = 0,1,\ldots,(N/2)-1.
\end{aligned}
$$

and the odd coefficients $R_k = X_{2k+1}$ as

$$R_k = R_k' - R_{k-1}$$

where

$$R_k' = \sqrt{\frac{2}{N}}\left\{\sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k+1)\pi}{2N} + \sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k-1)\pi}{2N}\right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1}(y_n - z'_n)2\cos\frac{(2n+1)\pi}{2N}\cos\frac{(2n+1)k\pi}{2(N/2)}\right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1}r_n\cos\frac{(2n+1)k\pi}{2(N/2)}\right\}$$

or

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\{\text{ length-N/2 DCT-II of } r_n\}$$

where

$$r_n = (y_n - z'_n)2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{\sqrt{\frac{2}{N/2}}\sum_{l=0}^{\frac{N}{2}-1}\varepsilon_l Y_l\cos\frac{(2n+1)l\pi}{2(N/2)} - \sqrt{\frac{2}{N/2}}\sum_{l=0}^{\frac{N}{2}-1}\varepsilon_l Z'_l\cos\frac{(2n+1)l\pi}{2(N/2)}\right\}2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{\sqrt{\frac{2}{N/2}}\sum_{l=0}^{\frac{N}{2}-1}\varepsilon_l(Y_l - Z'_l)\cos\frac{(2n+1)l\pi}{2(N/2)} - \right\}2\cos\frac{(2n+1)\pi}{2N}$$

$$= g_n 2\cos\frac{(2n+1)\pi}{2N}$$

where

g_n is a length-N/2 IDCT of $(Y_l - Z'_l)$, and where

$R'_k = X_{2k+1} + X_{2k-1}$.

or as

$$X_{2k+1} = \sqrt{\frac{2}{N}}\varepsilon_{2k+1}\sum_{i=0}^{N-1} x_i \cos\frac{(2i+1)(2\kappa+1)\pi}{2N}$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} x_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} x_{i+N/2}\cos\frac{(2i+N+1)(2k+1)\pi}{2N}\right\}$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} z_i \cos\left[\frac{(2i+1)(2k+1)\pi}{2N} + (k\pi + \frac{\pi}{2})\right]\right\}.$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + (-1)^{k+1}\sum_{i=0}^{\frac{N}{2}-1} z_i \sin\frac{(2i+1)(2k+1)\pi}{2N}\right\}$$

$$= \sqrt{\frac{2}{N}}(X1_k - (-1)^k X2_k), \quad k = 0,1,\ldots,(N/2)-1.$$

4. *(Amended)* [A] An encoder or decoder of [according to any of claims] claim 1 [- 3], wherein [**characterised in** that] N is equal to 2^m, m being a positive integer > 0.

Please cancel claims 5-8 without prejudice or disclaimer.

9. *(Amended)* A transcoder comprising the [an] encoder or decoder of [according to] claim 1.

10. *(Amended)* A system for transmitting DCT transformed image or video data comprising [an] the encoder or decoder of [according to] claim 1.

11. *(Amended)* A method of encoding a digitalized [an] image in [the] a compressed discrete cosine transform (DCT) domain[,] using DCTs of length [lengths] N/2, [and wherein the] comprising:

undersampling compressed frames [are undersampled] by a certain factor in each dimension, and [**characterised in** that an N x N]

calculating a DCT of length N x N [is] directly [calculated] from DCTs for four [4] adjacent [N/2xN/2] blocks of size N/2 x N/2 [DCT coefficients] of the digitalized image [incoming compressed frames], N being a positive, even integer.

12. *(Amended)* A method of encoding a digitalized [an] image represented as a discrete cosine transform (DCT) [DCT] transformed sequence of coefficients of length N, N being a positive, even integer, comprising:

[**characterised in** that the] calculating a DCT of length N [is calculated] directly from two sequences of coefficients of length N/2,

wherein the two sequences of coefficients are obtained from DCTs of length N/2 and represent [representing] the first half and second half, respectively, of [the] an original sequence of digitalized images values of length N.

13. *(Amended)* A method according to [any of claims 11 or] claim 12, [**characterised in** that] wherein the even coefficients of [a] the DCT of length N re calculated as:

$$X_{2k} = \sqrt{\frac{2}{N}}\varepsilon_{2k}\sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)2\kappa\pi}{2N}$$

$$= \sqrt{\frac{2}{N}}\varepsilon_k \left\{ \sum_{n=0}^{\frac{N}{2}-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=N/2}^{N-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} \right\}$$

$$= \sqrt{\frac{2}{N}}\varepsilon_k \left\{ \sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=0}^{\frac{N}{2}-1} x_{N-1-n} \cos\left[\frac{[2(N-1-n)+1]\kappa\pi}{2(N/2)}\right] \right\}$$

$$= \sqrt{\frac{1}{2}} \left\{ \sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1} z_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} \right\}$$

$$= \sqrt{\frac{1}{2}}\left[Y_k + (-1)^k Z_k\right]$$

$$= \sqrt{\frac{1}{2}}\left[Y_k + Z'_k\right] \qquad k = 0,1,\ldots,(N/2)-1.$$

and the odd coefficients $R_k = X_{2k+1}$ as

$$R_k = R_k^{'} - R_{k-1}$$

where

$$R_k^{'} = \sqrt{\frac{2}{N}} \left\{ \sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k+1)\pi}{2N} + \sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k-1)\pi}{2N} \right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}} \left\{ \sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1} (y_n - z'_n) 2\cos\frac{(2n+1)\pi}{2N} \cos\frac{(2n+1)k\pi}{2(N/2)} \right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}} \left\{ \sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1} r_n \cos\frac{(2n+1)k\pi}{2(N/2)} \right\}$$

or

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}} \text{ \{ length-N/2 DCT-II of } r_n \text{ \}}$$

where

$$r_n = (y_n - z'_n)2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{ \sqrt{\frac{2}{N/2}} \sum_{l=0}^{\frac{N}{2}-1} \varepsilon_l Y_l \cos\frac{(2n+1)l\pi}{2(N/2)} - \sqrt{\frac{2}{N/2}} \sum_{l=0}^{\frac{N}{2}-1} \varepsilon_l Z'_l \cos\frac{(2n+1)l\pi}{2(N/2)} \right\} 2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{ \sqrt{\frac{2}{N/2}} \sum_{l=0}^{\frac{N}{2}-1} \varepsilon_l (Y_l - Z'_l) \cos\frac{(2n+1)l\pi}{2(N/2)} - \right\} 2\cos\frac{(2n+1)\pi}{2N}$$

$$= g_n 2\cos\frac{(2n+1)\pi}{2N}$$

where

g_n is a length-N/2 IDCT of $(Y_l - Z'_l)$, and where

$R'_k = X_{2k+1} + X_{2k-1}$.

or as

$$X_{2k+1} = \sqrt{\frac{2}{N}} \varepsilon_{2k+1} \sum_{i=0}^{N-1} x_i \cos\frac{(2i+1)(2\kappa+1)\pi}{2N}$$

$$= \sqrt{\frac{2}{N}} \left\{ \sum_{i=0}^{\frac{N}{2}-1} x_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} x_{i+N/2} \cos\frac{(2i+N+1)(2k+1)\pi}{2N} \right\}$$

$$= \sqrt{\frac{2}{N}} \left\{ \sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} z_i \cos\left[\frac{(2i+1)(2k+1)\pi}{2N} + (k\pi + \frac{\pi}{2})\right] \right\}.$$

$$= \sqrt{\frac{2}{N}} \left\{ \sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + (-1)^{k+1} \sum_{i=0}^{\frac{N}{2}-1} z_i \sin\frac{(2i+1)(2k+1)\pi}{2N} \right\}$$

$$= \sqrt{\frac{2}{N}} (X1_k - (-1)^k X2_k), \quad k = 0,1,\ldots,(N/2)-1.$$

14. *(Amended)* [A] <u>The</u> method <u>of</u> [according to any of claims] <u>claim</u> 11 [- 13], **[characterised in** that] <u>wherein</u> N is equal to 2^m, m being a positive integer > 0.

15. *(Amended)* A method of decoding a digitalized [an] image represented as a discrete cosine transform (DCT) [DCT] transformed sequence of coefficients of length N, N being a positive, even integer, comprising:

[characterised in that the] calculating a DCT of length N [is calculated directly] from two sequences of coefficients of length N/2,

wherein the two sequences of coefficients represent [representing] the first half and second half, respectively, of [the] an original sequence of digitalized image values of length N.

16. *(Amended)* A method of decoding [an] a digitalized image in the compressed discrete cosine transform (DCT) [(DCT)] domain[,] using DCTs of lengths N/2, comprising: [and wherein the]

undersampling compressed frames [are undersampled] by a certain factor in each dimension, and

calculating a [**characterised in** that an N x N] DCT of length N x N [is] directly [calculated] from [4] DCTs for four adjacent [N/2 x N/2] blocks of sizes N/2 x N/2 of the digitalized image [DCT coefficients of the incoming compressed frames], N being a positive, even integer.

17. *(Amended)* [A] The method of [according to any of claims] claim 15 [or 16], wherein [**characterised in** that] the even coefficients of [a] the DCT of length N are calculated as:

$$\begin{aligned}
X_{2k} &= \sqrt{\frac{2}{N}}\varepsilon_{2k}\sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)2\kappa\pi}{2N} \\
&= \sqrt{\frac{2}{N}}\varepsilon_k\left\{\sum_{n=0}^{\frac{N}{2}-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=N/2}^{N-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)}\right\} \\
&= \sqrt{\frac{2}{N}}\varepsilon_k\left\{\sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=0}^{\frac{N}{2}-1} x_{N-1-n} \cos\left[\frac{[2(N-1-n)+1]\kappa\pi}{2(N/2)}\right]\right\} \\
&= \sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1} z_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)}\right\} \\
&= \sqrt{\frac{1}{2}}\left[Y_k + (-1)^k Z_k\right] \\
&= \sqrt{\frac{1}{2}}\left[Y_k + Z'_k\right] \qquad k = 0,1,\ldots,(N/2)-1.
\end{aligned}$$

and the odd coefficients $R_k = X_{2k+1}$ as

$$R_k = R_k^{'} - R_{k-1}$$

where

$$R_k^{'} = \sqrt{\frac{2}{N}}\left\{\sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k+1)\pi}{2N} + \sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k-1)\pi}{2N}\right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1}(y_n - z'_n)2\cos\frac{(2n+1)\pi}{2N}\cos\frac{(2n+1)k\pi}{2(N/2)}\right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1} r_n \cos\frac{(2n+1)k\pi}{2(N/2)}\right\}$$

or

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\{\text{ length-N/2 DCT-II of } r_n\}$$

where

$$r_n = (y_n - z'_n)2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{\sqrt{\frac{2}{N/2}}\sum_{l=0}^{\frac{N}{2}-1}\varepsilon_l Y_l \cos\frac{(2n+1)l\pi}{2(N/2)} - \sqrt{\frac{2}{N/2}}\sum_{l=0}^{\frac{N}{2}-1}\varepsilon_l Z'_l \cos\frac{(2n+1)l\pi}{2(N/2)}\right\}2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{\sqrt{\frac{2}{N/2}}\sum_{l=0}^{\frac{N}{2}-1}\varepsilon_l (Y_l - Z'_l)\cos\frac{(2n+1)l\pi}{2(N/2)} - \right\}2\cos\frac{(2n+1)\pi}{2N}$$

$$= g_n 2\cos\frac{(2n+1)\pi}{2N}$$

where

g_n is a length-N/2 IDCT of $(Y_l - Z'_l)$, and where

$R'_k = X_{2k+1} + X_{2k-1}$.

or as

$$X_{2k+1} = \sqrt{\frac{2}{N}}\varepsilon_{2k+1}\sum_{i=0}^{N-1} x_i \cos\frac{(2i+1)(2\kappa+1)\pi}{2N}$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} x_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} x_{i+N/2}\cos\frac{(2i+N+1)(2k+1)\pi}{2N}\right\}$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} z_i \cos\left[\frac{(2i+1)(2k+1)\pi}{2N} + (k\pi + \frac{\pi}{2})\right]\right\}.$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + (-1)^{k+1}\sum_{i=0}^{\frac{N}{2}-1} z_i \sin\frac{(2i+1)(2k+1)\pi}{2N}\right\}$$

$$= \sqrt{\frac{2}{N}}(X1_k - (-1)^k X2_k), \quad k = 0,1,\ldots,(N/2)-1.$$

18. *(Amended)* [A] The method [according to any] of [claims] claim 15 [- 17], [**characterised in** that] N is equal to 2^m, m being a positive integer > 0.

19. *(Amended)* A method of transcoding a digitalized [an] image in the compressed discrete cosine transform (DCT) domain[,] using DCTs of lengths N/2, comprising:

[and wherein the] undersampling compressed frames [are undersampled] by a certain factor in each dimension, [**characterised in** that an N x N] and

calculating a DCT of length N x N [is] directly [calculated] from DCTs of length N/2 x N/2 for four [4] adjacent [N/2xN/2] blocks of size N/2 x N/2 of the digitalized image [DCT coefficients of the incoming compressed frames], N being a positive, even integer.

20. *(Amended)* An encoder comprising:

- means for performing discrete cosine transform (DCT) transformation [DCT tranformation] of a sequence of values of length N/2 to produce two sequences of coefficients of length N/2, N being a positive, even integer, and [**characterised by**]

- means for calculating the DCT of length N directly from the two sequences of coefficients of length N/2 without having to calculate a DCT of length N,

wherein the two sequences of coefficients represent [representing] the first half and second half, respectively, of an original sequence of values of length N [N/2 only using DCTs of length N/2].

21. *(Amended)* A method of encoding <u>a digitalized</u> [an] image represented as <u>an original</u> [a] sequence of <u>values of</u> length N, N being a positive, even integer, <u>wherein</u> [**characterised in** that] the DCT of length N is calculated directly from two sequences of <u>coefficients obtained from DCTs of sequence of values of</u> length N/2 <u>without having to calculate a DCT of length N, the two sequences</u> representing the first <u>half</u> and second half<u>, respectively,</u> of <u>the</u> [an] original sequence of <u>values of</u> length N [only using DCTs of length N/2].

Please add new claims 22-26 as follows:

22. *(New)* A method of transmitting a bit stream representing a digitalized image as a compressed video signal which includes coefficients obtained by calculating DCTs for blocks of size N/2 x N/2, the blocks being obtained by dividing the digitalized image, to a plurality of users, at least one of which requires a reduction of the bit stream or down-scaling of the corresponding compressed video signal, the method comprising:

receiving in a transcoder the bit stream of the compressed video signal;

extracting from the received bit stream the coefficients for the blocks of size N/2 x N/2;

collecting the extracted coefficients for four adjacent blocks of size N/2 x N/2, the groups of four adjacent blocks forming together non-overlapping blocks of size N x N in the digitalized image;

calculating, from the collected coefficients, coefficients of the DCTs for the blocks of size N x N using DCTs and IDCTs of length N/2 and without using DCTs or IDCTs of length N or using DCTs and IDCTs for blocks of the size N/2 x N/2 and without using DCTs or IDCTs of length N x N,

selecting, from the calculated coefficients, coefficients of the lowest frequencies; and

transmitting to the at least one user a bit stream including only the selected coefficients.

23. *(New)* A method of transmitting a bit stream representing a digitalized image as a compressed video signal, which includes coefficients obtained by calculating DCTs for blocks of size N x N, the blocks being obtained by dividing the digitalized image, to a plurality of users, at least one of which requires a reduction of the bit stream or down-scaling of the corresponding compressed video signal, the method comprising:

receiving in a transcoder the bit stream of the compressed video signal;

extracting, from the received bit stream, the coefficients for the blocks of size N x N;

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collecting the extracted coefficients for four adjacent blocks of size N x N, the groups of four adjacent blocks forming together non-overlapping blocks of size 2N x 2N in the digitalized image;

selecting, from the collected, extracted coefficients for each block of size N x N of each of the groups of four adjacent blocks of the size N x N, coefficients of N/2 x N/2 lowest frequencies;

calculating, from the selected coefficients for each of the groups, coefficients of the DCT for a block of size N x N using DCTs and IDCTs of length N/2 and without using DCTs or IDCTs of length N or using DCTs and IDCTs for blocks of size N/2 x N/2 and without using DCTs or IDCTs of length N x N, and

transmitting to the at least one user a bit stream including only the calculated coefficients.

24. *(New)* The method of claim 23, wherein, in the step of calculating coefficients of DCTs for blocks of size N x N the even coefficients of a DCT of length N is calculated as:

$$\begin{aligned}
X_{2k} &= \sqrt{\frac{2}{N}}\varepsilon_{2k}\sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)2\kappa\pi}{2N} \\
&= \sqrt{\frac{2}{N}}\varepsilon_k\left\{\sum_{n=0}^{\frac{N}{2}-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=N/2}^{N-1} x_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)}\right\} \\
&= \sqrt{\frac{2}{N}}\varepsilon_k\left\{\sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sum_{n=0}^{\frac{N}{2}-1} x_{N-1-n} \cos\left[\frac{[2(N-1-n)+1]\kappa\pi}{2(N/2)}\right]\right\} \\
&= \sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1} y_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)} + \sqrt{\frac{2}{N/2}}\varepsilon_k\sum_{n=0}^{\frac{N}{2}-1} z_n \cos\frac{(2n+1)\kappa\pi}{2(N/2)}\right\} \\
&= \sqrt{\frac{1}{2}}\left[Y_k + (-1)^k Z_k\right] \\
&= \sqrt{\frac{1}{2}}\left[Y_k + Z'_k\right] \qquad k = 0,1,\ldots,(N/2)-1.
\end{aligned}$$

and the odd coefficients $R_k = X_{2k+1}$ as

$$R_k = R_k^{'} - R_{k-1}$$

where

$$R_k^{'} = \sqrt{\frac{2}{N}}\left\{\sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k+1)\pi}{2N} + \sum_{n=0}^{N-1} x_n \cos\frac{(2n+1)(2k-1)\pi}{2N}\right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1} (y_n - z'_n) 2\cos\frac{(2n+1)\pi}{2N}\cos\frac{(2n+1)k\pi}{2(N/2)}\right\}$$

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}}\left\{\sqrt{\frac{2}{N/2}}\varepsilon_k \sum_{n=0}^{\frac{N}{2}-1} r_n \cos\frac{(2n+1)k\pi}{2(N/2)}\right\}$$

or

$$= \frac{1}{\varepsilon_k}\sqrt{\frac{1}{2}} \{ \text{ length-N/2 DCT-II of } r_n \}$$

where

$$r_n = (y_n - z'_n) 2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{\sqrt{\frac{2}{N/2}} \sum_{l=0}^{\frac{N}{2}-1} \varepsilon_l Y_l \cos\frac{(2n+1)l\pi}{2(N/2)} - \sqrt{\frac{2}{N/2}} \sum_{l=0}^{\frac{N}{2}-1} \varepsilon_l Z'_l \cos\frac{(2n+1)l\pi}{2(N/2)}\right\} 2\cos\frac{(2n+1)\pi}{2N}$$

$$= \left\{\sqrt{\frac{2}{N/2}} \sum_{l=0}^{\frac{N}{2}-1} \varepsilon_l (Y_l - Z'_l) \cos\frac{(2n+1)l\pi}{2(N/2)} - \right\} 2\cos\frac{(2n+1)\pi}{2N}$$

$$= g_n 2\cos\frac{(2n+1)\pi}{2N}$$

where

g_n is a length-N/2 IDCT of (Y_l - Z'_l), and

$R'_k = X_{2k+1} + X_{2k-1}$,

or as

$$X_{2k+1} = \sqrt{\frac{2}{N}}\varepsilon_{2k+1}\sum_{i=0}^{N-1} x_i \cos\frac{(2i+1)(2\kappa+1)\pi}{2N}$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} x_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} x_{i+N/2}\cos\frac{(2i+N+1)(2k+1)\pi}{2N}\right\}$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + \sum_{i=0}^{\frac{N}{2}-1} z_i \cos\left[\frac{(2i+1)(2k+1)\pi}{2N} + (k\pi + \frac{\pi}{2})\right]\right\}.$$

$$= \sqrt{\frac{2}{N}}\left\{\sum_{i=0}^{\frac{N}{2}-1} y_i \cos\frac{(2i+1)(2k+1)\pi}{2N} + (-1)^{k+1}\sum_{i=0}^{\frac{N}{2}-1} z_i \sin\frac{(2i+1)(2k+1)\pi}{2N}\right\}$$

$$= \sqrt{\frac{2}{N}}(X1_k - (-1)^k X2_k), \quad k = 0,1,\ldots,(N/2)-1.$$

25. *(New)* A transmission system for transmitting digitalized images where users are connected to each other through a multi-node control unit and bit streams of digitalized images corresponding to compressed video signals are transmitted between the users, the compressed video signal including coefficients obtained by calculating discrete cosine transforms (DCTs) for blocks of size N/2 x N/2 obtained by dividing the digitalized image,

- a first one of the users, for receiving a bit stream transmitted from a second one of the users, requiring a reduction of the bit stream or down-scaling of the corresponding compressed video signal,

the multi-node control unit comprising:

- means for receiving said bit stream from the second one of the users and for extracting from the bit stream coefficients for blocks of size N/2 x N/2 in a corresponding digitalized image;

- means for collecting the extracted coefficients for four adjacent blocks of size N/2 x N/2;

- means for calculating from the collected coefficients coefficients for a DCT for a block of size N x N using DCTs and IDCTs of length N/2 and without using DCTs or IDCTs of length N or using DCTs and IDCTs for blocks of size N/2 x N/2 and without using DCTs or IDCTs of length N x N;

- means for selecting, from the calculated coefficients, coefficients for the lowest frequencies, and

- means for transmitting to the first one of the users a bit stream including only the selected coefficients.

26. *(New)* A transmission system for transmitting digitalized images, the system including users connected to each other through a multi-node control unit,

- bit streams of digitalized images being compressed video signals being transmitted between the users, the compressed video signal for a digitalized image comprising coefficients obtained by calculating DCTs for blocks of size N x N obtained by dividing the digitalized image,

- a first one of the users, for receiving a bit stream transmitted from a second one of the users, requiring a reduction of the bit stream or down-scaling of the corresponding compressed video signal,

the multi-node control unit comprising:

- means for receiving said bit stream from the second one of the users and for extracting from the bit stream coefficients for blocks of size N x N in a corresponding digitalized image;

- means for collecting the extracted coefficients for four adjacent blocks of size N x N;

- means for selecting, from the extracted coefficients for each of the four adjacent blocks, coefficients for N/2 x N/2 lowest frequencies;

- means for calculating, from the selected coefficients, coefficients for a DCT for a block of size N x N using DCTs and IDCTs of length N/2 and without using DCTs or IDCTs of length N or using DCTs and IDCTs for blocks of size N/2 x N/2 and without using DCTs or IDCTs of length N x N; and

- means for transmitting to the first one of the users a bit stream including only the calculated coefficients. --

ABSTRACT

A Discrete Cosine Transform (DCT) for an entire original sequence is obtained using the DCT coefficients representing the first half and the second half of the original sequence. This is useful when calculation of DCTs of a certain length is supported by hardware and/or software and different size DCTs must be calculated. Example areas of application include still image and video transcoding and scalable image and/or video coding.